Aging, Neuropsychology, and Cognition, 13:1–20

ISSN: 1382-5585/05 print; 1744-4128 online
DOI: 10.1080/138255890968682

Psychology Press
Taylor & Francis Group

Directed Forgetting in Older Adults Using the Item and List Methods

SANDRA A. SEGO[1], JONATHAN M. GOLDING[2] AND LAWRENCE R. GOTTLOB[2]
[1]American International College and [2]University of Kentucky

ABSTRACT

Four experiments investigated age-group differences in directed forgetting. Experiments 1A and 1B used the item method with recall (1A) and recognition (1B). Both of these experiments showed evidence of directed forgetting for both younger and older adults. The list method was used in Experiments 2A (recall) and 2B (recognition). For these experiments, there was directed forgetting when recall, but not recognition, was the dependent measure. Again, these results were found for younger and older adults. These results are discussed in terms of how different presentation types lead to the use of different theoretical mechanisms of directed forgetting (e.g., differential encoding, retrieval inhibition). Thus, it appears that both older and younger adults engage in adaptive memory strategies.

How effective are instructions to forget? Over the past 30 years research on the directed forgetting effect has shown that young adults can use these instructions in many different contexts to reduce proactive interference (see Bjork (1998), Golding & Long (1998), and MacLeod (1998) for recent reviews) and thus allow for an adaptive use of memory (see Anderson & Milson, 1989; Kraemer & Golding, 1997). Investigating this effect typically involves presenting a person with some information that is subsequently designated as "to-be-forgotten" (TBF) or irrelevant through the use of a forget cue. Following this forget cue, the person is then presented with to-be-remembered (TBR) or relevant information. The effectiveness of the forget cue is shown by lower recall of the TBF information, and higher recall of the TBR information, compared to a control group instructed to remember all of the information. Moreover, research has indicated that the lower recall of the TBF information is not the result of demand characteristics (i.e., participants

Address correspondence to: Jonathan M. Golding, University of Kentucky, Department of Psychology, Lexington, KY 40506-0044. E-mail: golding@uky.edu 1 simply withhold TBF items during memory tasks; see R. A. Bjork & Woodward (1973), MacLeod (1999), and Woodward & Bjork (1971)).

Two presentation methods are used in directed-forgetting experiments—item and list. Directed forgetting associated with each of the two methods has been shown to be the result of different cognitive mechanisms that manifest themselves at either encoding or retrieval (see Basden et al., 1993). When the item method of presentation is used, encoding explanations are generally favored (e.g., Bjork, 1972). In the item method, participants are presented with a list of words and each word is individually cued as TBF or TBR (e.g., MacLeod, 1975, 1989). This methodology is thought to lead to (1) segregation in memory of the TBF and TBR items; and (2) selective rehearsal of only the TBR items (Bjork, 1970; 1972). This selective encoding hypothesis suggests that each item is maintained in active memory until the cue is presented and then, if the cue is to remember the item, it is processed further (i.e., rehearsed). When the cue is to forget, that item is dropped from active memory and it is not rehearsed further. Evidence for these mechanisms is quite robust for both recall and recognition (see MacLeod, 1998).

When the list (or block) method is used, TBF and TBR words are presented in separate lists and the instruction to forget is typically presented after an initial list (e.g., Epstein, 1972; Geiselman et al., 1983). The selective encoding explanation that has been applied to the item method has not fared so well when applied to the list method. For example, the selective encoding hypothesis is not able to explain directed forgetting that has been observed for incidentally learned items in a list-method experiment, as investigated by Geiselman et al. (1983). In this experiment, participants engaged in both intentional and incidental learning, as a result of exposure to mixed lists containing (1) words to be learned for later recall, or (2) words to be judged for pleasantness. Participants were told that they did not have to learn the to-be-judged words. Therefore, any learning of these judged words was assumed to be incidental. After presenting list 1, some participants were told that what they had done so far was practice and that they should forget the to-be-learned words, while other participants were told that this was the halfway point in the list. All participants were then presented with list 2. Finally, all participants were asked to recall or recognize all of the words that they had been presented, both the to-be-learned words and the to-be-judged words, regardless of the instruction in the middle of the two lists. The to-be-judged words should not have been rehearsed because participants were instructed not to learn them. Thus, there was no reason for differential rehearsal of the to-be-judged words presented before the forget instruction and the to-be-judged words presented after the forget instruction. Directed forgetting was obtained, however, for both the intentionally learned items and for the incidentally learned (judged) words. Participants who were instructed to forget list 1 recalled fewer learn and judge words from list 1 compared to participants who were told it was the halfway point. Furthermore, participants who were instructed to forget list 1 recalled more learn-and-judge words from list 2 than participants who were not told to forget list 1. Therefore, Geiselman et al. concluded that access to the list 1 items was inhibited by the forget instruction (see also Basden et al., 1993; Bjork, 1989, 1998).

Further support for retrieval inhibition over selective encoding in the list method comes from findings of release from inhibition. If TBF items have been encoded and are actually in memory but are "forgotten" because their retrieval has been inhibited, then the TBF items may be retrieved if a release from inhibition occurs. This release from inhibition may be caused by presenting the items again, as on a recognition task, where retrieval processes are not as critical. In support of this idea, Geiselman et al. (1983) did not find directed forgetting for those participants who received a recognition test. That is, recognition of list 1 items was equal for participants who had been told to forget them and for participants who had been told it was the halfway point. Recognition of the list 2 items did not differ for participants who were told to forget list 1 and for participants who had been told it was the halfway point.

The selective encoding and retrieval inhibition explanations of directed forgetting have been conceptualized in terms of distinctive and relational processing (Basden et al., 1993). These types of processing are viewed as endpoints along a continuum of processing and are present in any memory task to varying degrees (Hunt & Einstein, 1981). When the item method is used, individuals primarily use distinctive processing as they deal with each word on a distinct or one-at-a-time basis. Each item and its associated forget or remember cue makes it more distinct from the other items in the list. When the list method is used, participants are presumably using relational processing to relate the words to each other and encode the items together, making it relatively easy to inhibit a list of TBF.

Much has been learned about directed forgetting in terms of encoding and retrieval mechanisms. These mechanisms have also been of particular interest in the study of age-related changes in memory performance (Burke & Light, 1981; Craik, 1977). Age-related decrements include a decline in total recall, which has been attributed to lower secondary (or long-term) memory performance (Delbec-Derousesne & Beauvois, 1989), and an age-related decline in the Sternberg memory scanning task (e.g., Madden, 1982). In addition, memory span measures suggest decreases in short-term memory span with increasing age (Salthouse & Babcock, 1991) that could lead to less storage capacity available for older adults during working memory tasks (see Hasher & Zacks, 1988).

To date, there have been only two published directed-forgetting studies that have specifically targeted older adults: Pavur et al. (1984) and Zacks et al., (1996). Pavur et al. (1984) used release from inhibition as a measure, whereas the three experiments in Zacks et al. (1996) used recall and recognition of TBR and TBF items. Pavur et al. used a variation of the item method ("get" vs. "don't get" items on a shopping list), and Zacks et al. used both the item method (Experiments 1A and 1B) and list method (Experiments 2 and 3). In addition to presentation method, presentation rate and cue duration also varied: Pavur et al. (1984) presented the items verbally at a rate of one item every 4 seconds, while Zacks et al. (1996) presented the words visually for 5 seconds.

There were other important differences in method. Among the three item-method experiments, Pavur et al. used cues that were simultaneous with the target words (e.g., "get shoelaces" vs. "don't get bread"), whereas Zacks et al. (1996, Experiments 1A and 1B) used "R" or "F" letters presented immediately after (but not coincident with) the target words. In the list-method experiments, Zacks et al. (Experiments 2 and 3) gave their participants immediate tests on the TBR words after presentation of the two lists on a trial. After all trials, participants were tested on their (delayed) recall of all the words that had been presented—both the TBR words and the TBF words.

Pavur et al. (1984) showed equivalent effects of directed forgetting with younger and older adults. However, they noted that lack of power in their design may have limited the generality of their conclusions. In addition, they used a release-from-inhibition measure which is difficult to compare with the recall and recognition measures from both Zacks et al. (1996) and the current studies. Therefore, we will compare the present results to those of Zacks et al. who found directed forgetting for both younger and older adults on a final recall and recognition task. Their age-group differences were manifested in a greater absolute magnitude of TBR-TBF difference for younger as compared to older adults (Experiments 1A and 1B). This was the result of the absolute number of TBF words remembered in the delayed test being about equal for the age groups, but the younger adults remembering more TBR words than the older group.

Despite the differences in methodologies and results, all of the studies mentioned above argue for inhibition as the mechanism that leads to directed forgetting. Although Pavur et al. (1984) does not specify the type of inhibition present in their study, Zacks et al. suggest that the results are due to "attentional inhibition," which they suggest occurs in working memory. For example, Zacks et al. (1996) suggest that inhibition ordinarily works to suppress the activation of irrelevant information in working memory. Hasher and Zacks (1988) argue that attentional inhibition keeps irrelevant information from entering working memory and quickly removes information that is no longer useful. Older adults, however, cannot inhibit irrelevant information as well as younger adults (Hartman &

Hasher, 1991; Hasher & Zacks, 1988; and Tipper, 1991). Once older adults activate an idea or a concept, it is maintained and is not inhibited, even when evidence suggests that it is no longer required (see also Hartman and Hasher, 1991).

The present study will investigate directed forgetting in older adults by using methodologies that can be compared more directly to existing data in the directed forgetting literature (see MacLeod, 1998). To this end, Experiments 1A and 1B will use a variation of the item method that has been used in directed forgetting research for over 30 years (see MacLeod, 1998). Experiments 2A and 2B will use the learn-judge procedure developed by Geiselman et al. (1983) in their classic directed forgetting study using the list method. It is hoped that using more traditional directed forgetting methodologies, and measuring both strategies and relative performances in TBF and TBR conditions, will allow us to (a) extend the previous findings of Zacks et al. (1996), and (b) further investigate the attentional inhibition hypothesis of Hasher and Zacks (1988).

EXPERIMENTS 1A AND 1B

This pair of experiments was designed to investigate directed forgetting of older adults using the item method with different dependent measures (Experiment 1A – recall, Experiment 1B – recognition). Unlike previous studies with older adults, these experiments used a directed forgetting methodology that was comparable to the vast majority of the directed forgetting literature (see MacLeod, 1998). Thus, younger and older adult participants were presented with a single list of unrelated words in which an explicit cue to forget or remember was paired randomly with each word. After list presentation and a distracter task, participants were asked to recall or recognize all of the words at one time. The use of separate recall and recognition experiments was to avoid cross-contamination between the two tests (see Geiselman et al., 1983). It was predicted that younger adults would have greater overall recall and recognition performance than older adults. If directed forgetting was evident and was due to selective encoding, recall and recognition of the TBF words should be lower than recall of the TBR words.

It should be noted that half of the participants were given the explicit cues simultaneously with the word, as in Pavur et al. (1984), while half of the participants were given the cue after the word was presented, as in Zacks et al. (1996). Participants who were presented with the memory cue simultaneously with the word may have chosen to not encode the to-be-forgotten items at all; if this were the case, this presumably more efficient selection should produce a strong recall and recognition deficit for TBF words (i.e., greater DF with simultaneous cuing than delayed cuing).

METHOD

Participants

The participants included 60 undergraduates from the University of Kentucky (aged 18 to 30; *M* = 19.0, *SD* = 2.0), who received partial course credit for participating. There were also 60 older adult volunteers (aged 64 to 88; *M* = 72.2, *SD* = 5.3) recruited from the Sanders-Brown Center at the University of Kentucky. The older adults, by self-report, had not been diagnosed with any form of memory or visual impairment and did not live in an assisted-living facility. The older adults (*M* = 15.62, *SD* = 2.82) had significantly more years of schooling than the younger adults (*M* = 12.67, *SD* = 1.04), $t\ (118) = 9.11$, $p < .001$. Participants completed either Experiment 1A or 1B.

Design

Each Experiment (1A and 1B) consisted of a 2 (memory cue) × 2 (age group) × 2 (cue timing) mixed-factors design. Memory cue was a within-participants factor and included to-be-remembered and to-be-forgotten items. Age group had two levels: younger and older. The final factor of cue timing designated the timing of the remember/forget cue; it was either simultaneous with or after the presentation of the target word. In Experiment 1A, participants completed a recall test, whereas in Experiment 1B, participants completed a recognition test.

Materials

The materials included a list of 24 unrelated words (see Appendix A). These words were all concrete nouns between four and nine letters. The list of words was split into two parts. For each participant, half of the list was presented as TBR, while the other half of the list constituted the TBF words and vice versa. The TBR and TBF words were randomly intermixed. The recognition test included 24 distracters (see Appendix B). Both studied words and distracters were counterbalanced across participants.

Procedure

Initially, participants filled out some descriptive information about themselves (e.g., age and years of education). They were then presented with the directed forgetting task. Participants were presented with the list of words on an IBM-compatible PC screen. For participants in the delayed-cue timing condition, each word was presented for 5 seconds in the center of the screen and the cue to remember or forget-the-word followed for 1 second one line below where the word appeared. In the simultaneous-cue timing condition, the word and memory cue were both presented for 5 seconds and the memory cue remained on the screen for an additional second (one line below the word), to equate the presentation times with the delayed condition. The cue to remember was "REMEMBER," and the cue to forget was "FORGET, presented in capital letters.

After the entire list was presented, participants engaged in a distracter task for approximately 5 minutes (drawing and labeling a map of the United States), which was intended to eliminate a recency effect. Following the distracter task, participants were asked to either recall (Experiment 1A) or recognize (Experiment 1B) all of the words that they were presented, regardless of whether the word was to-be-remembered or to-be-forgotten. In the recognition task, participants were presented with a sheet that included 48 words (all 12 TBF words, all 12 TBR words, and 24 distractors). Participants were asked to circle any word that had been presented, regardless of the memory cue that was presented with the word. Debriefing followed recall or recognition.

RESULTS

Experiment 1A

Recall

A 2 (age group) × 2 (cue timing) × 2 (memory cue) mixed-factors analysis of variance (ANOVA) was conducted on the number of TBR and TBF words recalled. This analysis yielded significant main effects of memory cue, $F(1, 56) = 337.27$, $MSE = .01$, $p < .001$, $\eta^2 = .86$ and age group, $F(1, 56) = 51.55$, $MSE = .02$, $p < .001$, $\eta^2 = .48$. These results were qualified by a significant age group × memory cue interaction, $F(1, 56) = 60.22$, $MSE = .01$, $p < .001$, $\eta^2 = .52$. This interaction was due to increased recall of the TBR words by younger adults. As shown in Table 1, younger adults recalled a significantly higher proportion of TBR words than TBF words, demonstrating the directed forgetting effect, $t\ (29) = 17.99$, $p < .001$, $\eta^2 = .92$. Older adults also showed this pattern, $t\ (29) = 6.87$, $p < .001$, $\eta^2 = .62$. Finally, whereas younger participants recalled more TBR words than older adults, $t\ (58) = 7.83$, $p < .001$, $\eta^2 = .51$, the two age groups did not differ in recall of the TBF words, $t\ (58) < 1$.

TABLE 1. Proportion Recall as a Function of Memory Cue and Age Group in Experiment 1A

	Younger Adults	Older Adults
TBF Words	.08 (.09)	.08 (.07)
TBR Words	.64 (.15)	.31 (.18)

SDs in parentheses.

TABLE 2. Proportion Recall as a Function of Memory Cue, Age Group, and Cue Timing in Experiment 1A

	Younger Adults		Older Adults	
	Simultaneous Cue	Delayed Cue	Simultaneous Cue	Delayed Cue
TBF Words	.10 (.08)	.07 (.10)	.07 (.06)	.09 (.08)
TBR Words	.70 (.13)	.59 (.16)	.38 (.13)	.23 (.20)

SDs in parentheses.

There was also an unexpected interaction of Cue timing × Memory cue, F (1, 56) = 8.10, MSE = .01, $p < .01$, $\eta^2 = .13$ (see Table 2). Follow-up analyses on this interaction showed that directed forgetting was evident for each type of cue timing. Participants in the simultaneous-cue condition recalled significantly more TBR words (M = .54, SD = .21) than TBF words (M = .08, SD = .07), t (29) = 11.97, $p < .001$, $\eta^2 = .83$. Participants in the delayed-cue condition also recalled more TBR words (M = .41, SD = .25) than TBF words (M = .08, SD = .09), t (29) = 6.98, $p < .001$, $\eta^2 = .63$. Participants in the simultaneous-cue condition recalled significantly more TBR words than participants in the delayed-cue condition, t (58) = 2.14, $p < .05$, $\eta^2 = .07$. Participants in the simultaneous and delayed-cue conditions did not differ in their recall of the TBF items, t (58) < 1, although this result is tempered by the fact that TBF performance is near floor in all conditions. A reasonable post-hoc explanation of this interaction is that simultaneous cues allow better encoding of the TBR word.

Experiment 1B

Recognition

A 2 (age group) × 2 (cue timing) × 2 (memory cue) mixed-factors ANOVA was conducted on the mean proportion of to-be-remembered and TBF words recognized by the participants (see Table 3). As with recall, there was a significant main effect of memory cue F(1, 56) = 110.25, MSE = .03, $p < .001$, $\eta^2 = .66$. The TBR words (M = .87, SD = .16) were recognized more than TBF (M = .53, SD = .24). There was also a main effect of age group, F(1, 56) = 7.60, MSE = .05, $p < .008$; $\eta^2 = .12$, younger adults

TABLE 3. Proportion Recognition as a Function of Memory Cue and Age Group in Experiment 1B

	Younger Adults	Older Adults
TBF Words	.59 (.19)	.48 (.28)
TBR Words	.93 (.10)	.81 (.19)

SDs in parentheses.

TABLE 4. Proportion Recognition as a Function of Memory Cue, Age Group, and Cue Timing in Experiment 1B

	Younger Adults		Older Adults	
	Simultaneous Cue	Delayed Cue	Simultaneous Cue	Delayed Cue
TBF Words	.56 (.19)	.60 (.19)	.41 (.30)	.54 (.26)
TBR Words	.94 (.07)	.91 (.13)	.84 (.17)	.77 (.19)

SDs in parentheses.

(M = .75, SD = .11) recognized significantly more words than older adults (M = .64, SD = .18). The age group × memory cue interaction was not significant, $F(1, 56) < 1$.

The cue timing × memory cue interaction (previously found for recall, above) was again significant, $F(1, 56) = 5.01$, $MSE = .03$, $p < .05$, $\eta^2 = .08$ indicating that the difference between TBF and TBR words was greater in the simultaneous condition than the delayed-cue condition (see Table 4). Participants in both cue timing conditions showed directed forgetting. Participants in the simultaneous-cue timing condition recognized a higher proportion of TBR words (M = .89, SD = .14) than TBF words (M = .48, SD = .25), $t\ (29) = 7.63$, $p < .001$, $\eta^2 = .67$. Participants in the delayed-cue condition also recognized a higher proportion of TBR words (M = .84, SD = .18) than TBF words (M = .57, SD = .23), $t\ (29) = 7.69$, $p < .001$, $\eta^2 = .67$. Participants in the simultaneous and delayed-cue timing conditions did not differ in the proportion of TBR words they recognized, $t\ (58) = 1.34$, $p = .19$, $\eta^2 = .03$. Furthermore, participants in the simultaneous-cue timing condition did not differ from participants in the delayed-cue timing condition on recognition of the TBF words, $t\ (58) = 1.42$, $p = .16$, $\eta^2 = .03$.

DISCUSSION

The results from Experiments 1A and 1B showed that younger adults recalled and recognized more words than older adults. In addition, there was evidence of directed forgetting for both younger and older adults for both recall and recognition. Although older adults did not have the same reduction in interference as younger adults on recall, the older participants did show significantly lower TBF recall than TBR recall. These results are strikingly consistent with the results from the final recall task in Experiment 1B from Zack's et al. (1996). For example, the level of TBF recall in the present study was .08 for both age groups (significantly different from 0, but still near floor), whereas in Zacks et al. this level was .11. Thus, it did not seem to be the case that older adults had significant difficulty in using explicit cues to forget effectively, although in Experiment 1A the absolute magnitude of the directed forgetting effect was smaller for older adults (.23) than for younger adults (.56). As for the mechanism leading to directed forgetting, the pattern of results across both recall and recognition appear to support a differential encoding explanation for both age groups (see Basden et al., 1993).

Experiments 2A and 2B

Will older adults show evidence of directed forgetting using the list method? This second pair of experiments investigated this question using the Geiselman et al. (1983) learn-judge paradigm with recall (Experiment 2A) and recognition (Experiment 2B). Participants were presented with two lists of words; half of each list was to be learned, and half of each list was to be judged on the basis of pleasantness. An instruction to forget list 1 was presented to half of the participants (forget group). The other participants were to remember both list 1 and list 2 (remember group).

Using the above methodology, directed forgetting would be evident if there was an interaction between the list 1 memory cue presented (forget/remember; a between-participants variable) and list of words (list 1/list 2; a within-participants variable). The forget group should have lower recall of list 1 (TBF words) than the remember group. In addition, the forget group's ability to "edit out" list 1 should increase list 2 memory performance compared to the remember group. Finally, only the forget group should have memory of list 1 lower than that of list 2.

When examining the data, there are two important questions that need to be addressed. First, there is a question of whether directed forgetting will be found for both recall and recognition. This is a critical point in the directed forgetting literature (e.g., Bjork, 1998). As stated earlier, many directed forgetting researchers would argue that the list method encourages relational processing, and it is this type of processing that leads to retrieval inhibition. However, some researchers (e.g., Zacks et al., 1996) who have investigated older adults have not made the recall-recognition distinction when discussing the mechanisms leading to directed forgetting. With regard to the recall versus recognition distinction and aging, if older adults have reduced inhibition it may be that they do not show a release from inhibition as has been found by other directed forgetting researchers using younger adults (e.g., Geiselman et al., 1983). Younger adults should show evidence of directed forgetting on recall but not recognition. Older adults should show a reduction of directed forgetting on recall compared to the younger adults, and no directed forgetting on recognition. Second, is directed forgetting found for both learn and judge words? Directed forgetting should be found for learn words. Geiselman et al. (1983) argued that if directed forgetting is found for judge words it indicates that retrieval inhibition was likely leading to directed forgetting, since these words should be incidentally learned (i.e., should not be rehearsed).

METHOD

Participants

The participants included 60 undergraduates from the University of Kentucky. They received partial course credit for participating. There were also 60 older adult volunteers recruited from the Sanders-Brown Center at the University of Kentucky, with the same exclusion criteria as for Experiment 1. The mean age for the younger adults was 18.67 (*SD* = 1.14; aged 17 to 24), and the mean age for the older adults was 71.73 (*SD* = 5.75; aged 62–89). The older adults (*M* = 14.70, *SD* = 2.38) had significantly more years in school than the younger adults (*M* = 12.32, *SD* = .68), $t\,(118) = 7.46$, $p < .001$. Thirty participants completed Experiment 2A (recall) and another group of 30 participants completed 2B (recognition). None of these individuals participated in Experiment 1.

Design

Each experiment consisted of a 2 (memory cue) × 2 (task) × 2 (list) × 2 (age group) mixed-factors design. The between-participants factor of memory cue had two levels: (a) remember—remember list 1 and list 2; and (b) forget—forget list 1, remember list 2. The age-group factor had two levels: older adults or college age adults. All other variables were within-participants factors. The task variable was to learn vs. judge each word for pleasantness. There were two lists; list 1 and list 2. After presentation of the list, each participant was given either a free recall test (Experiment 2A) or a recognition test (Experiment 2B).

Each word appeared equally often as a to-be-learned word and as a to-be-judged word. The words were presented equally often as list 1 words and list 2 words and as learn and judge words.

Materials

The materials for both Experiments 2A and 2B included 48 unrelated words consisting of concrete nouns between four and nine letters (see Appendix C). Due to the additional within-participants factor of task, the number of words presented was increased in Experiments 2A and 2B compared to the initial experiments. The recognition test included all 48 studied words plus 48 distracters (see Appendix D). Both studied words and distracters were counterbalanced across participants.

Procedure

Participants initially filled out some descriptive information about themselves (e.g., age and years of education). They were then presented with the directed forgetting task. Participants were told that two studies were being conducted simultaneously to save time. One study was examining how memorable certain words were and one was examining how people judge words for pleasantness. Participants were explicitly told that the to-be-judged words were not to be learned. These words were to be judged on a separate sheet of paper using a rating scale of 1 (not at all pleasant) to 7 (extremely pleasant). The lists were presented on IBM-compatible computers. To be consistent with Experiment 1, the words were presented for 5 seconds with 1 second between each word. The screen was blank between presentations of the words. The presentation of the to-be-learned words was alternated with the to-be-judged words. The words were presented as LEARN ___ or JUDGE ___.

When participants completed list 1, those in the remember condition were presented with a screen which informed them that they were halfway through the list:

> "The first portion of the list has now been presented; continue to try to remember the to-be-learned words that have been presented."

Participants in the forget condition were told the following:

> "What you have done so far has been practice; therefore, you should forget about all of the to-be-learned words that have been presented. The list you will see next is the one we want you to remember, so forget the practice list and concentrate on this new list." (Basden et al., 1993; Geiselman et al., 1983).

After the second list was presented, participants engaged in a distracter task for approximately 5 minutes (drawing and labeling a map of the United States) to eliminate any short-term memory effects. Following this task, participants were asked to either recall (Experiment 2A) or recognize (Experiment 2B) all of the words that they were presented, regardless of the instruction in the middle of the list. Recognition test participants in Experiment 2B were given a sheet of paper with 96 words on it. Half of the words were distracters. Participants were asked to circle any words that they recognized from the list; regardless of whether the word was to-be-learned or to-be-judged and regardless of the instruction in the middle of the list. Following this task, the participants were debriefed.

RESULTS

Experiment 2A

Recall

A 2 (memory cue) × 2 (list) × 2 (age group) × 2 (task) mixed-factors ANOVA was conducted on the proportion of words recalled. This analysis yielded a significant main effect of memory cue, $F(1, 56) = 6.21$, $MSE = .03$, $p < .02$, $\eta^2 = .10$ and list, $F(1, 56) = 10.06$, $MSE = .01$, $p < .002$, $\eta^2 = .15$.

TABLE 5. Proportion Recall for the Forget Cue and Remember Cue Conditions as a Function of Age Group and List in Experiment 2A

	Younger Adults		Older Adults	
	List 1	List 2	List 1	List 2
Forget Cue	.35(.13)	.45(.11)	.07(.05)	.20(.06)
Remember Cue	.48(.14)	.45(.10)	.19(.14)	.19(.09)

SDs in parentheses.

These were qualified by a significant memory cue × list interaction, $F(1, 56) = 18.15$, $MSE = .01$, $p < .001$, $\eta^2 = .25$. (The results are presented in Table 5 for the forget cue and remember cue conditions as a function of age group and list.) For list 1, participants in the forget condition ($M = .21$, $SD = .17$) recalled fewer words from list 1 than participants in the remember condition ($M = .33$, $SD = .20$), $t\ (58) = 2.56$, $p < .02$, $\eta^2 = .10$. For list 2, participants in the forget condition ($M = .32$, $SD = .16$) did not differ from the participants in the remember condition ($M = .32$, $SD = .16$) in the number of words recalled from list 2, $t\ (58) < 1$. For participants in the forget condition, significantly fewer words from list 1 were recalled than from list 2, $t\ (29) = 5.04$, $p < .001$, $\eta^2 = .47$. The participants in the remember condition did not differ in the number of words recalled from list 1 and list 2, $t\ (29) < 1$.

The ANOVA also yielded significant main effects of age group, $F(1, 56) = 133.79$, $MSE = .03$, $p < .001$, $\eta^2 = .71$ and task, F(1, 56) = 20.06, MSE = .02, p < .001, $\eta^2 = .26$. These main effects were qualified by a significant age group × task interaction (see Table 6), $F(1, 56) = 36.32$, $MSE = .02$, $p < .001$, $\eta^2 = .39$. Younger participants ($M = .52$, $SD = .16$) recalled significantly more to-be-learned words than older participants ($M = .15$, $SD = .08$), $t\ (58) = 11.44$, $p < .001$, $\eta^2 = .69$. In addition, younger participants ($M = .34$, $SD = .09$) recalled significantly more to-be-judged words than older participants ($M = .17$, $SD = .11$), $t\ (58) = 6.41$, $p < .001$, $\eta^2 = .42$. The younger participants recalled significantly more to-be-learned words than to-be-judged words, $t\ (29) = 5.79$, $p < .001$, $\eta^2 = .54$. Older adults did not differ in the proportion of to-be-learned and to-be-judged words recalled, $t\ (29) = 1.88$, $p = .07$, $\eta^2 = .11$. It should be noted that the age group × memory cue interaction was not significant, $F(1, 56) < 1$.

TABLE 6. Proportion Recall of To-Be-Learned and To-Be-Judged Words as a Function of Age Group in Experiment 2A

	Younger Adults	Older Adults
To-Be-Learned Words	.52 (.16)	.15 (.08)
To-Be-Judged Words	.34 (.09)	.17 (.11)

SDs in parentheses.

Experiment 2B

Recognition

A 2 (memory cue) × 2 (list) × 2 (age group) × 2 (task) mixed-factors ANOVA was conducted on the mean proportion of recognized words. (The results are presented in Table 7 for the forget cue and remember cue conditions as a function of age group and list.) This analysis yielded a significant main effect of memory cue, $F(1, 56) = 7.45$, $MSE = .04$, $p < .01$, $\eta^2 = .12$. Participants recognized more words when they had to remember both lists ($M = .74$, $SD = .16$) than if they had to forget list 1 and remember list 2 ($M = .67$, $SD = .19$). This finding is consistent with Zacks et al. (1996, Experiment 1B) who found a main effect of memory cue on the final recognition task presented to their participants. Unlike that for recall, the memory cue × list interaction was not significant, $F(1, 56) < 1$.

There was also a significant main effect of age group $F(1, 56) = 126.00$, $MSE = .04$, $p < .001$, $\eta^2 = .69$. This was qualified by a significant age group × task interaction, $F(1, 56) = 7.59$, $MSE = .03$, $p < .01$, $\eta^2 = .12$. This interaction was the result of a greater age-group difference for learn words (young adults $M = .87$, $SD = .10$; older adults $M = .52$, $SD = .12$), $t\ (58) = 11.61$, $p < .001$, $\eta^2 = .70$ than for judge words (younger adults $M = .83$, $SD = .17$; older adults $M = .60$, $SD = .12$), $t\ (58) = 5.85$, $p < .001$, $\eta^2 = .37$.

Finally, there was a significant main effect of list, $F(1, 56) = 12.21$, $MSE = .023$, $p < .001$ that was qualified by a significant list × task interaction, $F(1, 56) = 4.12$, $MSE = .023$, $p < .05$, $\eta^2 = .07$. Follow-up comparisons indicated that to-be-judged words from list 1 ($M = .76$, $SD = .17$) were recognized better than to-be-learned words from list 1 ($M = .71$, $SD = .22$), $t\ (59) = 2.79$, $p < .01$, $\eta^2 = .12$. Also, to-be-judged words from list 1 were recognized better than to-be-judged words from list 2 ($M = .66$, $SD = .25$), $t\ (59) = 3.40$, $p < .001$, $\eta^2 = .16$. No other comparisons were reliable (to-be-learned words from list 2 $M = .68$, $SD = .22$). These findings may reflect effects of levels of processing on recognition, which may have some undetermined component of implicit memory.

TABLE 7. Proportion Recognition for the Forget Cue and Remember Cue Conditions as a Function of Age Group and List in Experiment 2B

	Younger Adults		Older Adults	
	List 1	List 2	List 1	List 2
Forget Cue	.86 (.08)	.77 (.18)	.55 (.17)	.50 (.11)
Remember Cue	.91 (.06)	.85 (.13)	.63 (.07)	.57 (.10)

SDs in parentheses.

DISCUSSION

The results from Experiments 2A showed evidence of directed forgetting for both younger and older adults. Specifically, both younger and older adults recalled fewer TBF words than TBR words across lists. In addition, both younger and older adults had lower recall of TBF words in the forget condition than in the remember condition. This pattern of results was found for learn words as well as for judge words. Contrary to predictions, recall of TBR words was not greater for participants in the forget condition compared to the remember condition (Table 5). This result was true for both younger and older adults. The failure to benefit from forgetting may have been due to the extra degree of segregation between list 1 and list 2 when the list method (as opposed to the item method) is used; additional research will be necessary to understand the conditions under which TBR word recall is increased.

Zacks et al. (1996) found that the difference between TBF and TBR words was greater on recall and recognition for younger than older adults. The present results, however, showed that there was no evidence of directed forgetting on recognition in Experiment 2B for either age group. Although there was a main effect of memory cue, there was no memory cue $\times$ list interaction indicative of directed forgetting. Moreover, the pattern of results across lists (list 1 > list 2) was opposite to that expected with directed forgetting, and opposite to that found in Experiment 2A with recall. Taken together, these results (i.e., directed forgetting on recall and no directed forgetting on recognition) offer support for retrieval inhibition as the mechanism leading to directed forgetting (Basden et al., 1993; Geiselman et al., 1983) when the list method is used.

GENERAL DISCUSSION

The present study used traditional directed-forgetting methodology to investigate the ability of older adults to intentionally forget. The results showed that both younger and older adults showed evidence of directed forgetting, although for the latter group the magnitude of directed forgetting was reduced. This pattern of results was evident whether the item method (Experiments 1A and 1B) or the list method (Experiments 2A and 2B) of presentation was used. When using the item method, directed forgetting was found for both recall and recognition, whereas for the list method, directed forgetting was only present when a recall test was used.

These results are consistent with previous theoretical explanations of directed forgetting corresponding to the two types of presentation, item and list (Basden et al., 1993). The results point to some strong generalities in performance during the directed forgetting task across both younger and older adults. The item method (Experiment 1) led to differential encoding due to distinctive processing of each word as it was presented. Conversely, when the list method was used (Experiment 2), participants of both ages exhibited directed forgetting on recall (Experiment 2A). When a recognition test was used (Experiment 2B), neither age group showed directed forgetting, which was consistent with the hypothesis that retrieval inhibition interferes with recall but not recognition.

In addition to the similarities in performance shared by younger and older adults, there were also some age-group differences. For recall using the item method (Experiment 1A) there was a significant age group × memory cue interaction, due to an age-related decrease in recall performance on TBR words (.64 for younger vs. .31 for older), but age-group equivalence for TBF words (.08). These results are similar to the recall results found in Zacks et al. (1996). In their Experiment 1A, they found an interaction of age group × memory cue, with TBR-TBF differences higher for younger (TBR = .52; TBF = .25) than older adults (TBR = .35; TBF = .16). In their Experiment 1B, Zacks et al. found TBR-TBF differences, in terms of both absolute magnitude and ratio, higher for younger adults (TBR = 44.1; TBF = 11.1) than for older adults (TBR = 25.5; TBF = 11.3). These results were interpreted along other data, as evidence for an inhibition deficit in older adults.

We would not want to argue with the Zacks et al. inference of an age-related inhibition deficit. There is evidence from their study (e.g., TBF intrusion rates during immediate TBR recall) and from other research involving distinguishing relevant from irrelevant information (e.g., Hartman & Hasher, 1991; May et al., 1999) in support of decreased inhibition of irrelevant information by older adults. For example, Hartman and Hasher (1991) and May et al. (1999) investigated the garden-path sentence completion task with younger and older adults. In this task, participants read sentences that are missing the final word (e.g., "She ladled the soup into her ___.") Participants had to predict the missing word (e.g., "bowl"), but then an unexpected but acceptable target word was provided (e.g., "lap"). A subsequent implicit memory test was then used to determine access to the two alternative ending words. This task was very much like a directed forgetting experiment in which the predicted word serves as a TBF word and the unexpected word is a TBR word. The results from these studies showed that older adults continue to retain both words, whereas younger adults only retain the target.

However, for all of the recall and recognition tasks in Zacks et al. (1996), as well as the current results, TBF performance for older adults never exceeded that of younger adults. (While floor effects may have contributed to the age-group equality in TBF performance in our Experiment 1A, and in Zacks et al. Experiment 1B, it is important to note that both groups were at floor.) It may be argued, though, that for TBF words, absolute recall/recognition level is not an appropriate index of inhibition, and that TBR-TBF difference or ratio is a better measure.

The lower TBR performance for older adults on both recall (Experiments 1A and 2B) and recognition (Experiments 1B and 2B) is consistent with the general theme of age-related memory decrements (see Light (1996), and Zacks et al., (2000) for reviews). Possible causes for these decrements (in addition to the inhibition deficit hypothesis) include reductions in attentional resources and reductions in speed of processing. It is likely that factors underlying the lower TBR performance for the older adults also affected their overall performance, so it would be difficult to establish the unique contribution of directed forgetting to the age differences in TBF performance.

Why do the present list-method experiments lead to a different pattern of results compared to Zacks et al. (1996, Experiment 2)? The inconsistency may be due to different testing procedures used in the present study and Zacks et al. The present study employed traditional directed-forgetting methodologies (i.e., testing TBF and TBR memory after a short delay), whereas Zacks et al. used immediate recall of TBR words plus a final free recall of both TBF and TBR words. In addition, the presentation of multiple lists in Zacks et al. may have affected both immediate recall tests and the delayed recall test. For example, the immediate recall tests could have served as additional practice for the retrieval of the TBR items. This may have magnified age-group differences if, for instance, younger adults benefited more from TBR-word practice than older adults.

Another issue is that the preservation of directed forgetting in the face of generalized age-group deficits may be due to the sample of older adults used in the present study. As is common in many other cognitive aging studies, the older participants in the present studies probably function cognitively at a higher level than that of the general population of older adults, which may raise issues of representativeness. It appears from the current results that both age groups show evidence of directed forgetting, although older participants clearly had overall lower levels of performance and a reduction in directed forgetting.

In summary, the present results indicate that older adults have retained the capability of engaging in strategies that render TBF information inaccessible, when they are directed to forget a subset of information that is to be retained for later recall or recognition. Thus, the implication is that strategic reallocation of resources through specific mechanisms (e.g., differential encoding with the item method) (Bjork, 1972) can help to preserve levels of function even in the face of declining overall levels of performance.

ACKNOWLEDGMENT

This research was part of the first author's dissertation thesis.

REFERENCES

Anderson, J. R., & Milson, R. (1989). Human memory: An adaptive perspective. *Psychological Review*, *96*, 703–719.

Basden, B., Basden, D., & Gargano, G. (1993). Directed forgetting in implicit and explicit memory tests: A comparison of methods. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*, 603–616.

Bjork, R. A. (1970). Positive forgetting: The noninterference of items intentionally forgotten. *Journal of Verbal Learning and Verbal Behavior*, *9*, 255–268.

Bjork, R. A. (1972). Theoretical implications of directed forgetting. In A. W. Melton & E. Martin (Eds.), *Coding processes in human memory* (Vol. , (pp. 217–235). Washington DC: Winston.

Bjork, R. A. (1989). Retrieval inhibition as an adaptive mechanism in human memory. In H. L. Roediger & F. I. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (pp. 309–330). Hillsdale, NJ: Erlbaum.

Bjork, R. A. (1998). Intentional forgetting in perspective. In J. M. Golding & C. M. MacLeod (Eds.), *Intentional forgetting: Interdisciplinary approaches* (pp. 453–481). Mahwah, NJ: Erlbaum.

Bjork, R. A., & Woodward, A. E (1973). Directed forgetting of individuals words in free recall. *Journal of Experimental Psychology*, *99*, 22–27.

Burke, D. M., & Light, L. L. (1981). Memory and aging: The role of retrieval processes. *Psychological Bulletin*, *90*, 513–546.

Craik, F. I. M. (1977). Age differences in human memory. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 384–420). New York: Van Nostrand Reinhold Co.

Delbec-Derousesne, J., & Beauvois, M. F. (1989). Memory processes and aging: A defect of automatic rather than controlled processes?. *Archives of Gerontology and Geriatrics Supplement*, *1*, 121–150.

Epstein, W. (1972). Mechanisms of directed forgetting. In G. H. Bower (Ed.), *The psychology of learning and motivation.* Vol. 6, (pp. 147–191). New York: Academic Press.

Geiselman, R. E., Bjork, R. A., & Fishman, D. L. (1983). Disrupted retrieval in directed forgetting: A link with posthypnotic amnesia. *Journal of Experimental Psychology: General*, *112*, 58–72.

Golding, J. M., & Long, D. L. (1998). There's more to intentional forgetting than directed forgetting: An integrative review. In J. M. Golding & C. M. MacLeod (Eds.), *Intentional forgetting: Interdisciplinary approaches* (pp. 59–102). Mahwah, NJ: Erlbaum.

Hartman, M., & Hasher, L. (1991). Aging and suppression: Memory for previously relevant information. *Psychology and Aging*, *6*, 587–594.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. Bower (Ed.), *The psychology of learning and motivation.* Vol. 22 (pp. 193–225). NY: Academic Press.

Hunt, R. R., & Einstein, G. O. (1981). Relational and item-specific information in memory. *Journal of Verbal Learning and Verbal Behavior*, *20*, 497–513.

Kraemer, P. J., & Golding, J. M. (1997). Adaptive forgetting in animals. *Psychonomic Bulletin & Review*, *4*, 480–491.

Light, L (1996). Memory and aging. In E. L. Bjork & R. A. Bjork (Eds.), *Memory* (pp. 444–490). San Diego: Academic Press.

MacLeod, C. M. (1975). Long-term recognition and recall following directed forgetting. *Journal of Experimental Psychology: Human Learning and Memory*, *104*, 271–279.

MacLeod, C. M. (1989). Directed forgetting affects both direct and indirect tests of memory. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *15*, 13–21.

MacLeod, C. M. (1998). Directed forgetting: The human memory literature. In J. M. Golding & C. M. MacLeod (Eds.), *Intentional forgetting: Interdisciplinary approaches* (pp. 1–57). Mahwah, NJ: Erlbaum.

MacLeod, C. M. (1999). The item and list methods of directed forgetting: Test differences and the role of demand characteristics. *Psychonomic Bulletin & Review*, *6*, 123–129.

Madden, D. J. (1982). Age differences and similarities in the improvement of controlled search. *Experimental Aging Research*, *8*, 91–98.

May, C. P., Zacks, R. T., Hasher, L., & Multhaup, K. S. (1999). Inhibition in the processing of garden-path sentences. *Psychology and Aging*, *14*, 304–313.

Pavur, E. J., Comeaux, J. M., & Zeringue, J. A. (1984). Younger and older adults' attention to relevant and irrelevant stimuli in free recall. *Experimental Aging Research*, *10*, 59–60.

Salthouse, T. A., & Babcock, R. L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology*, *27*, 763–776.

Tipper, S. P. (1991). Less attentional selectivity as a result of declining inhibition in older adults. *Bulletin of the Psychonomic Society*, *29*, 45–47.

Woodward, A. E., & Bjork, R. A. (1971). Forgetting and remembering in free recall: Intentional and unintentional. *Journal of Experimental Psychology*, *89*, 109–116.

Zacks, R.T., Hasher, L., & Li, K. Z. H. (2000). Human memory. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 293–357). Mahwah, NJ: Erlbaum.

Zacks, R. T., Radvansky, G., & Hasher, L. (1996). Studies of directed forgetting in older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 143–156.

APPENDIX

APPENDIX A

Word list used in Experiments 1A and 1B

match	flower
shadow	bench
weapon	cork
uniform	office
turtle	flash
diamond	passage
satellite	embassy
reptile	insect
radish	wheat
meadow	tornado
forest	king
lamp	leaf

APPENDIX B

Distractor word list used in Experiments 1A and 1B

genius	porcupine
palace	frame
sheep	spider
motel	worm
statue	treasure
grape	ransom
galaxy	salmon
harbor	deputy
inch	attic
patch	scoop
trumpet	casino
grease	purse

APPENDIX C

Word list used in Experiments 2A and 2B

shadow	bench	cork
turtle	flash	passage
radish	forest	lamp
leaf	meadow	reptile
melon	carpet	palace
hunter	window	dish
prairie	obstacle	grape
picnic	casino	glove
match	flower	weapon
uniform	office	diamond
satellite	embassy	insect
wheat	tornado	king
plate	surgeon	emperor
spider	priest	quarter
raisin	salmon	senate
patch	film	harbor

APPENDIX D

Distractor word list used in Experiments 2A and 2B

locust	dragon	herring
genius	porcupine	attic
galaxy	roulette	bandit
sheep	motel	worm
statue	camel	chain
abode	treasure	ransom
mountain	acre	deputy
valve	notch	creek
freeway	heaven	scoop
trumpet	bride	studio
square	grease	purse
twig	clay	balloon
straw	sweater	inch
frame	elephant	vaccine
record	module	pearl
clover	track	milk